Annals of the Royal College of Surgeons of England (1977) *vol* 59

Movement patterns of intrinsic minus fingers

Role of intrinsic and extrinsic muscles in finger posture control

H Srinivasan FRCS FRCSEd

Senior Orthopaedic Surgeon, Central Leprosy Teaching and Research Institute, Chingleput, India

Summary

A detailed study of the patterns of two movements (pure metacarpophalangeal flexion and pure interphalangeal extension) in intrinsic minus fingers shows that the long extensors and long flexors produce simultaneous movement at the metacarpophalangeal and interphalangeal joints. A comparison of the patterns of these movements in totally intrinsic minus and interosseous minus fingers shows that in the latter the lumbricals are probably largely inactive during attempted pure metacarpophalangeal flexion and contribute to restrain metacarpophalangeal extension considerably during attempted pure interphalangeal extension. Active participation by the interosseous muscles appears necessary for completing these movements.

Introduction

Paralysis of the ulnar nerve alone or combined ulnar and median nerve paralysis is quite common in leprosy because of the tendency of *Mycobacterium leprae* to infect and destroy these nerves selectively[1]. The resulting motor paralysis is stable and undisturbed by other features like vascular insufficiency, articular disease, or injury to tendons or bone. Leprosy thus provides a good opportunity to study a large number of uncomplicated 'intrinsic minus' fingers (that is, fingers in which the intrinsic muscles are paralysed). This opportunity was taken and the patterns of certain movements were studied to see whether the empirical findings corroborated the present concepts of the action of extrinsic and intrinsic muscles. The salient findings are summarized here.

Material and methods

The movements were studied in 221 intrinsic minus fingers (60 hands) of 51 patients with leprosy (40 men, 11 women). Most of the patients were young adults in the age group 15–30 years and only 2 were 40 or over. The approximate duration of claw-finger deformity ranged from 3 months to over 20 years, the mean duration being 3 years and 10 months. Of the 221 fingers examined, 141 were totally intrinsic minus while the remaining 80 were 'interosseous minus', having paralysis of the interossei but not of the lumbrical muscles. The motor status of the fingers was determined by clinical examination and manual muscle testing. Fingers with doubtful motor status and those with contractures or other motor defects were not included.

Two movements were studied in these fingers in detail. These were: (1) pure metacarpophalangeal (MP) joint flexion (starting from the fully open position of the finger and flexing the MP joint only, keeping the interphalangeal (IP) joints as straight as possible); and (2) pure IP joint extension (starting from the fully closed position of the finger and extending only the IP joints). The postures undergone by the finger during the different stages of the test movement were determined by measuring the angles at the MP and the proximal interphalangeal (PIP) joints. A graphic representation of the test movement was then constructed by plotting these postures as points on a graph with the positions of the MP and PIP joints as the two coordinates and serially connecting the points. The movement pattern of each finger was recorded in this manner.

A qualitative evaluation of the movement patterns was made by visual appraisal of the shape of the curve depicting the movement. A quantitative analysis was made by working out mean patterns of the test movements in the two main groups and their subgroups identified by visual appraisal. Mathematical analysis of the curves depicting the various mean patterns was also carried out and slope curves for them obtained to enable valid comparisons of the different patterns to be made.

Totally intrinsic minus fingers

Pure metacarpophalangeal flexion Visual appraisal of the curves depicting attempted pure MP flexion in totally intrinsic minus fingers showed that this movement was accompanied from the beginning by flexion of the IP joints. The patterns of pure MP flexion movement of the 141 totally intrinsic minus fingers could be grouped as classical (35), semiclassical (69), or anomalous (37), depending on whether the degree of flexion of the PIP joint that occurred during the early stages of the test movement was judged by visual appraisal to be high, medium, or low. The mean patterns of these subgroups were accordingly different (Fig. 1*a*). However, the slope curves, which show the rate of change of the associated PIP flexion, were more or less similar (Fig. 1*b*), indicating that the three patterns identified by visual appraisal were not qualitatively different and that the classical and anomalous patterns were only extreme variations from the average, represented by the semiclassical pattern.

Normally, the movement of pure MP flexion is brought about by the intrinsic muscles (lumbricals and interossei)[2]. When there is total intrinsic paralysis the patient attempts to flex the MP joint with the long flexors, as they are the only muscles available for this movement. So the pattern of this movement in the totally intrinsic minus finger will give us the movement pattern that occurs when only the long flexors are acting.

It is the general view that isolated activity of the long flexors produces IP flexion initially and that MP flexion occurs only after flexion of the IP joints is exhausted or nearly exhausted[3-6]. This pattern of finger flexion is described as the finger closing on itself[4]. Empirical study of attempted pure MP flexion in totally intrinsic minus fingers shows that this concept is not quite true. It is seen that isolated activity of the long flexors causes simultaneous and not successive flexion of the IP and MP joints, and in a good proportion of cases the IP joints are not excessively flexed during MP flexion. The slope curve of the mean pattern of this movement in these fingers further shows that the IP flexion associated with attempted pure MP flexion is of a low order and that it takes place more or less at a steady rate for most of the test movement. IP flexion occurs at an increasing rate only during the late stages of MP flexion. The clinical impression of the totally intrinsic minus finger closing on itself on attempted MP flexion is, then, due to the initial posture of considerable flexion (about 50° on the average) at the PIP joint, so that any further flexion will make the finger curl up and close on itself and not because the long flexors preferentially flex the IP joints before flexing the MP joints.

Pure interphalangeal extension Visual appraisal of the curves depicting attempted

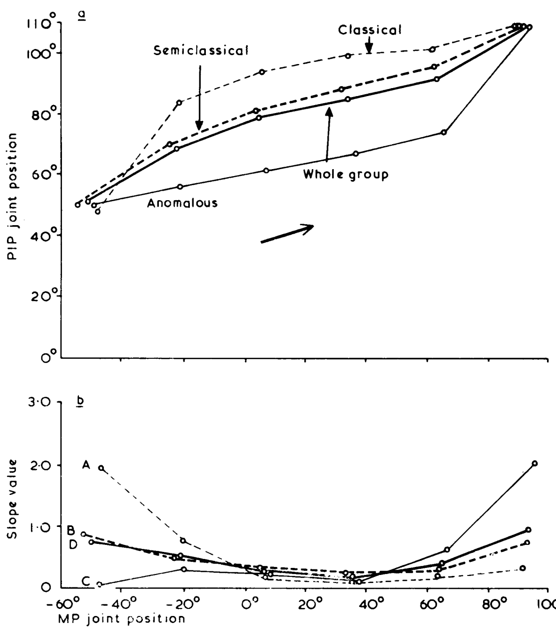

FIG. 1 *Attempted pure MP flexion in totally intrinsic minus fingers. (a) Mean patterns of movement. Positions of the two joints are recorded as angles of flexion. Negative angles indicate hyperextension. Thick arrow indicates direction of movement. (b) Slope curves of mean patterns: A, classical; B, semiclassical; C, anomalous; D, whole group.*

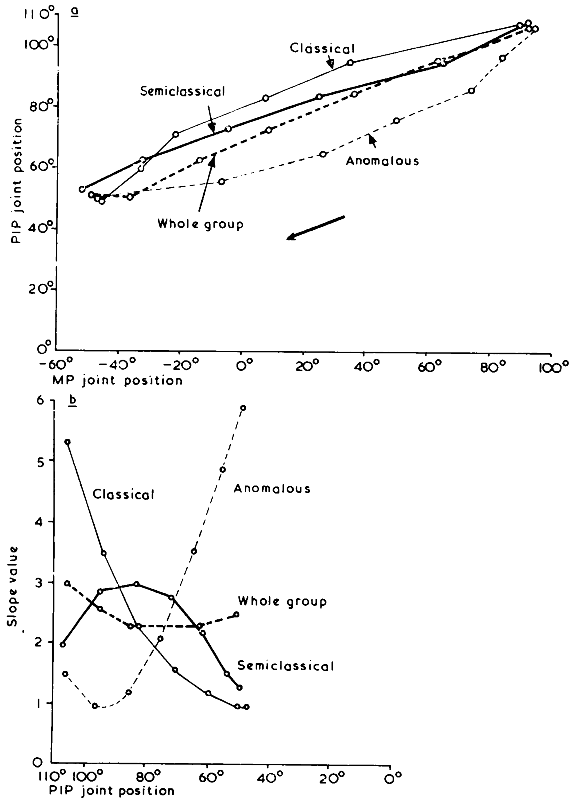

FIG. 2 *Attempted pure IP extension in totally intrinsic minus fingers. (a) Mean patterns of movement. (b) Slope curves of mean patterns.*

pure IP extension in totally intrinsic minus fingers showed that this movement was accompanied from the beginning by extension at the MP joint also. As in the case of MP flexion, the patterns of this movement could again be classified into three subgroups as classical, semiclassical, and anomalous according to whether the degree of MP extension associated with the early stages of IP extension was judged by visual appraisal to be high, medium, or low. The mean patterns of this movement in these subgroups were also found to be accordingly different (Fig. 2*a*), but the slope curves of the three patterns were quite dissimilar, indicating that these patterns were qualitatively different from one another (Fig. 2*b*). Further detailed analysis failed to reveal any associations between the different patterns and any of the known variables like the particular finger involved or the degree and duration of the claw-finger deformity. One is therefore forced to conclude that subtle anatomical variations of the extensor apparatus were probably responsible for the different patterns of movement.

The movement of pure IP extension is normally brought about by the intrinsic muscles[2]. In the totally intrinsic minus finger only the long extensor is available for this movement. It is generally held that the long extensor is primarily an extensor of the MP joint and that it can extend the IP joints only after completing or nearly completing MP extension[7,8]. It is also held by some that the IP joints will go into flexion if the extensor continues to act after the MP joint has started hyperextending[9,10]. The present study shows that these concepts are not quite correct. It is shown that isolated activity of the long extensor causes simultaneous, not successive, extension of the MP and IP joints. But the pattern of movement is not uniform and varies in different hands. It is also shown that in most fingers the IP extension that results from long extensor activity continues without interruption and that no IP flexion occurs. Only 10 fingers showed some IP flexion after initial extension, but even in these fingers the change occurred well before the MP joint started hyperextending.

Interosseous minus fingers

These were the fingers in which only the interossei were paralysed and both extrinsic muscles and lumbricals were available for carrying out the test movements. Eighty fingers of this type were studied.

Pure metacarpophalangeal flexion Visual appraisal of the curves depicting attempted pure MP flexion in the interosseous minus fingers showed that this movement was associated with a variable amount of IP flexion during its early stages. The movement pattern in 15% of fingers was near normal in that there was hardly any IP flexion, but the remaining 85% showed a more common pattern in which there was some associated IP flexion. However, the slope curves of the mean patterns of these two subgroups were quite similar, indicating that the two patterns were not qualitatively different.

Pure interphalangeal extension The movement patterns of attempted pure IP extension could also be classified by visual appraisal into a near normal or a more common pattern according to whether the MP extension associated with the early stages of IP extension was virtually absent (20%) or definitely present though of a low order (80%). As in the case of MP flexion patterns, the slope curves were quite similar, indicating that the two patterns were not qualitatively different.

Comparison of totally intrinsic minus and interosseous minus fingers

Comparison of the movement patterns of interosseous minus fingers with those of totally intrinsic minus fingers will show the effect of introducing lumbrical muscles in the totally intrinsic minus system, for any alteration in the former could only have been due to the active participation of lumbricals. Conclusions can also be drawn regarding the effect of isolated paralysis of the interossei and the role of the interosseous muscles in finger posture control. However, it must be remembered that inferences regarding the action of a muscle drawn from a comparison between normal and paralysed states can be fallacious and must be viewed with caution[8].

Pure metacarpophalangeal flexion Comparison of the mean pattern of attempted pure MP flexion of the interosseous minus finger with that of the totally intrinsic minus finger shows a striking improvement in the former (Fig. 3*a*). The test movement shows much greater independence in the interosseous minus finger in that the associated IP flexion is, for the most part, very much decreased. It may be reasonable to attribute this improvement to the active participation of the lumbrical muscles. But the slope curves (Fig. 3*b*) of the mean patterns of these two types of finger are quite similar, especially during the first 100° of MP flexion, indicating that the patterns are not qualitatively different. This suggests that the movement is probably brought about by the same agency, the long flexors, in both cases. The apparent improvement in the movement of the interosseous minus fingers is therefore attributable not to lumbrical participation but to the milder degree of clawing shown by these fingers.

In the interosseous minus finger the lumbrical is available for pure MP flexion and it must be acting at least at the beginning of the movement to keep the IP joints in maximum possible extension. But in view of its inefficiency when the MP joint is maximally extended the long flexor apparently comes into action to carry out this movement. As any activity of the long flexor inhibits lumbrical activity[11] the lumbrical will cease to act from then on and so will be unable to take any further part in the movement. This would account for the slight initial difference and the subsequent similarity in the slope curves of the mean pattern of MP flexion in these two types of finger. Interosseous participation therefore appears to be necessary for carrying out this

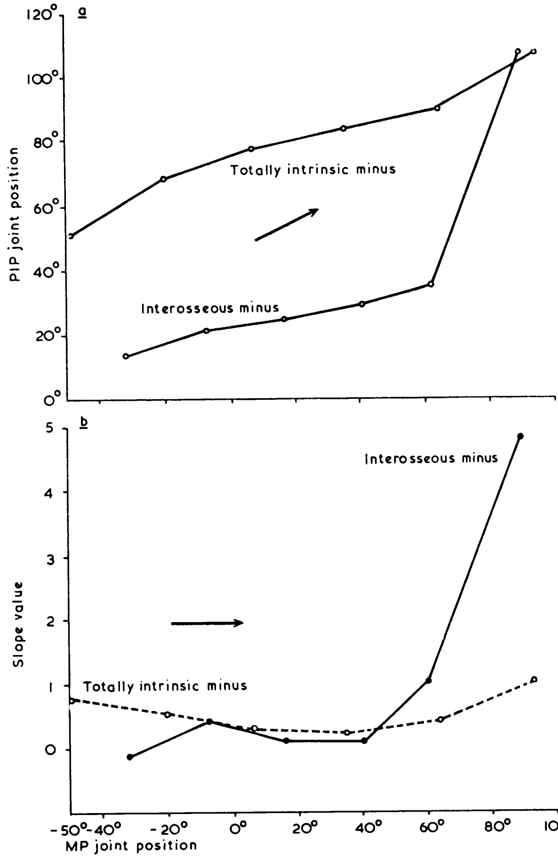

FIG. 3 *Attempted pure MP flexion. Comparison of (a) mean patterns of movement and (b) slope curves of mean patterns in totally intrinsic minus and interosseous minus fingers.*

movement efficiently. The rapidly increasing rate of increase in associated IP flexion during the terminal stage of the test movement in the interosseous minus fingers probably reflects only the availability of IP flexion in these fingers, which have a much greater range of active flexion at the IP joint because of a milder degree of clawing.

Pure interphalangeal extension The mean pattern of attempted pure IP extension of interosseous minus fingers is also quite different from that of totally intrinsic minus fingers in that there is much greater independence of the test movement in the former (Fig. 4*a*). The interosseous minus fingers are able to carry out pure IP extension with very much less associated MP extension. The slope curves of the mean patterns of these two types of finger are also quite dissimilar, showing that these patterns are truly different (Fig. 4*b*). The improvement of the pattern of IP extension in interosseous minus fingers can be attributed only to the active participation of the lumbricals.

MP extension occurs during attempted pure IP extension in the totally intrinsic minus finger because only the long extensor is available to carry out this movement. In the interosseous minus finger the active participation of the lumbrical apparently introduces an effective restraining force at the MP joint, preventing MP extension to a considerable extent during the first 60° of IP extension. But this restraint by the lumbrical muscle seems to become ineffective during further IP extension, and associated MP extension occurs at an increasing rate during the later stages. These observations suggest that lumbrical participation in the intrinsic minus system introduces a flexing force moment at the MP joint, preventing excessive hyperextension. This conclusion is strengthened by the milder claw-finger deformity seen in interosseous minus fingers compared with totally intrinsic minus fingers. It is therefore suggested that the lumbrical muscles are not mere extensors of the IP joints, incapable of causing MP flexion, as is generally maintained[12-14], and that their active participation introduces a flexing moment at the MP joint, though they are not very effective in this action during the end stages of IP extension. Participation by the interosseous muscles appears to be necessary to restrain the MP joints from extending, particularly during the later stages of IP extension. The inefficiency of the lumbricals when the MP joints are maximally extended and during the end stages of IP extension is probably due to excessive approximation of the origin and insertion of this muscle in these positions[15].

We may therefore conclude that interosseous participation is essential for carrying out fully the 'intrinsic motions' of pure MP flexion and pure IP extension. It is likely that the lumbrical muscles are responsible for the finer adjustments of finger posture whereas the interossei act as power muscles. The findings of Rabischong[16] that the lumbrical muscle is very

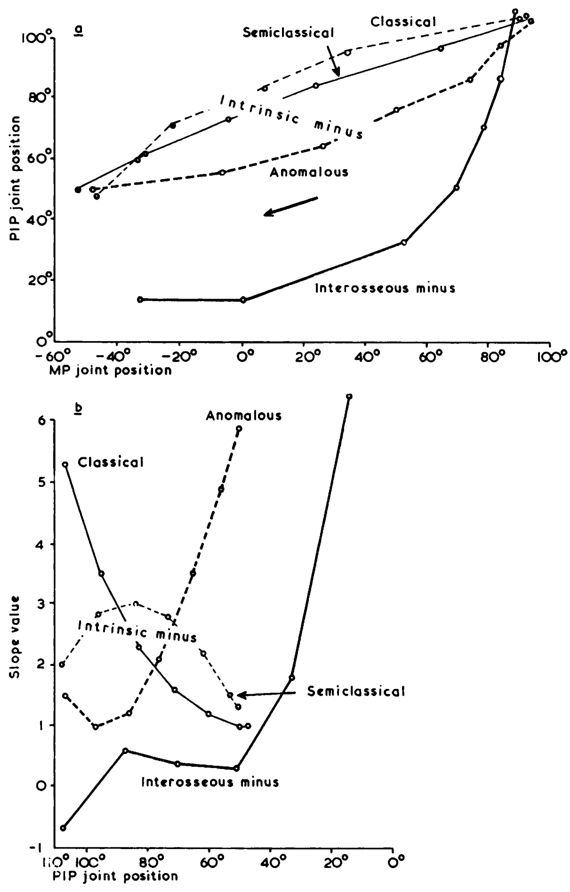

FIG. 4 *Attempted pure IP extension. Comparison of (a) mean patterns of movement and (b) slope curves of mean patterns in totally intrinsic minus and interosseous minus fingers.*

richly innervated and Long's observation[17] that only the lumbricals consistently participate during precision handling, whereas the interossei participate in most power grips with hardly any participation by the lumbrical muscles, lend support to this concept of lumbrical–interosseous activity.

Conclusions

The following conclusions regarding the extrinsic and intrinsic muscles may be drawn from this study of movement patterns of intrinsic minus fingers.

1) The long flexor causes simultaneous flexion of the IP and MP joints. MP flexion is usually achieved without excessive IP flexion.

2) The long extensor causes simultaneous extension of the MP and IP joints. But the pattern of the resulting movement is variable.

3) The lumbrical muscle is not just an extensor of the IP joints but contributes a flexing force moment at the MP joint. But this muscle is rendered inefficient when the MP joints are maximally hyperextended and during the terminal stages of IP extension.

4) Active participation of the interossei is necessary for completing the 'intrinsic movements'—that is, pure MP flexion and pure IP extension.

References

1 Brand, P W (1964) in *Leprosy in Theory and Practice,* ed. Cochrane, R G, and Davey, T F, 2nd edn, p 449. Bristol, Wright.

2 Long, C (1968) *Journal of Bone and Joint Surgery, 50A,* 973.

3 Duchenne, G B (1867) *Physiology of Motion Demonstrated by Means of Electrical Stimulation and Clinical Observation and Applied to Study of Paralysis and Deformities,* trans. and ed. by Kaplan, E B, p. 127. Philadelphia and London, Saunders.

4 Brand, P W (1958) *Journal of Bone and Joint Surgery, 40B,* 618.

5 Landsmeer, J M F (1962) *Annals of the Rheumatic Diseases, 21,* 164.

6 Zancolli, E (1968) *Structural and Dynamic Bases of Hand Surgery,* p. 21. London and Philadelphia, Pitman Medical–Lippincott.

7 Duchenne, G B (1867) *Physiology of Motion Demonstrated by Means of Electrical Stimulation and Clinical Observation and Applied to Study of Paralysis and Deformities,* trans. and ed. Kaplan, E B, p. 126. Philadelphia and London, Saunders.

8 Sunderland, S (1945) *American Journal of Anatomy, 76,* 189.

9 Mulder, J D, and Landsmeer, J M F (1968) *Journal of Bone and Joint Surgery, 50B,* 664.

10 Sarrafian, S K, Kazarian, L E, Topuzian, L K, Saraffian, V K, and Siegelman, A (1970) *Journal of Bone and Joint Surgery, 52A,* 980.

11 Long, C, Thomas, D, and Crochetiere, W J (1964) in *Proceedings of the Fourth International Congress of Physical Medicine,* Paris, 6–11 September, 1964, p. 440. International Congress Series No. 107. Amsterdam, Excerpta Medica.

12 Long, C, Brown, M E, and Weiss, G (1960) *Archives of Physical Medicine, 41,* 175.

13 Stack, H G (1963) *Annals of the Royal College of Surgeons of England, 33,* 307.

14 Thomas, D H, Long, C, and Landsmeer, J M F (1968) *Journal of Biomechanics, 1,* 107.

15 Srinivasan, H (1975) *Acta anatomica, 93,* 464.

16 Rabischong, P (1961) Cited by Stack (ref. 13).

17 Long, C (1970) *Normal and Abnormal Motor Control in the Upper Extremities, An Ampersand Report,* p. 17, Final Report, Social and Rehabilitation Services Grant No RD–2377–M, Cleveland.